Visual Dominance under the Choice and Simple Reaction Experiments

Tohoku Psychologica Folia
1992, **52**, 26-32

VISUAL DOMINANCE UNDER THE CHOICE AND SIMPLE REACTION EXPERIMENTS

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Visual dominance under visual and auditory reaction tasks was examined. Eleven subjects were presented a series of stimuli consisting of a light and a tone in random alteration. They had two response keys, one for the light and one for the tone in the choice reaction task, and one response key for both stimuli in the simple reaction task. On occasional trials, both stimuli were presented simultaneously. In this case, the subjects responded to the stimulus that they perceived first. In both reaction tasks, the responses to the light were found to be much more than the responses to the tone on the paired trials. This finding suggests that vision dominates over audition in the bimodal reaction tasks. The results are discussed in terms of the information processing stages.

Key words: visual dominance, non-discordant stimuli, bimodal reaction task, choice of responses.

INTRODUCTION

In multimodal perceptual situations, the visual input often tends to dominate over the other modalities. For instance, when one looks at one's hand through a wedge prism, the hand feels to be at the location where it is seen (Pick, Warren, & Ikeda, 1965). In many studies of intersensory biases, visual dominance has been observed in the solution of sensory conflicts. However, visual dominance also occurs in non-discordant situations (e.g., Colavita,1974; Jordan, 1972; Teghtsoonian & Teghtsoonian, 1970).

Colavita (1974) found that the light was perceived first in trials where the light and tone were presented simultaneously, and inserted into the light and tone choice reaction-time task. The strength of the tone used in his experiment was equated subjectively to the strength of the light. Using a simple reaction time paradigm, the tone was responded to more quickly than the light. Therefore, if the two stimuli were presented simultaneously, the tone was expected to be perceived first and responded to preferentially. The responses, however, were almost always to the light. This phenomenon is called visual dominance in information flow (Posner & Rogers, 1978)

Some studies have given explanations to account for the visual dominance. Colavita (1974) discussed his results in the context of a hard-wiring of the nervous system in which the visual channel may be sampled first by virtue of its more direct connections with the superior colliculus. But he himself objected to this account before long. Colavita and Weisberg (1979) found that the offset of stimuli rather than the onset facilitated visual dominance. The hard-wiring theory could not account for the changes of visual bias by onset and offset of the stimuli. Then they suggested that the offset of light increases attention to vision and facilitated visual dominance.

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Posner, Klein, and Nissen (1976) also accounted for the visual dominance by attention. They suggested that the visual stimuli should be allocated relatively more attention since the vision is inherently less alerting. But it is not clear why attention is allocated to the vision involuntarily to the extent that the vision dominates over the other modalities rather than only compensating for its lack in alertness.

In contrast to this involuntary sensory process, Egeth and Sager (1979) found that the visual dominance was influenced by voluntary attention. An instruction to attend to a specific modality increases the tendency to response to its stimulus. In consequence, they concluded that visual dominance in the bimodal reaction task is not a sensory phenomenon like masking, but an attentional phenomenon. However, even if the visual dominance was interrupted by voluntary attention, we could not say that visual dominance might result from it.

To account for the visual dominance in the non-discordant situation between vision and audition, the information processing stage where the visual bias occurred was examined in this study. Reaction processes that have been widely discussed (e. g., Sanders, 1980; Teichner & Krebs, 1974; Welford, 1980) can be divided into four stages, that is, reception of signal, identification of signal, choice of response, and the initiation of action. If the stage where the bias has occurred could be specified, the cause of visual dominance effect would be inferred.

Among these information processing stages, the choice of response stage was specifically investigated since Hohnsbein et al. (1991) showed that divided attention between vision and audition caused a strong impairment of response selection process in audition. They used the letters "F" and "J" as visual stimuli and the sound "F" and "J" (German pronunciation) as auditory stimuli. Their subjects had two keys, one for visual and auditory F, and one for J. Reaction time and event-related potentials were measured and analyzed. The present study is a slightly different situation because selection is not between the letters or sounds, but between two modalities. The response selection stage was manipulated based on the supposition that it influences visual dominance.

The present study employed the bimodal reaction task as Colavita's (1974) paradigm with light and tone. The experiment was based on the hypothesis that the process of the response selection between two modalities is important for visual dominance. If the task needs a choice of response, vision will dominate over audition. On the other hand, if the task does not need a choice of response, we will not find visual dominance.

METHODS

Subjects: The subjects were 11 undergraduate students. All were naive to this experiment. The data of one male had to be discarded because of an excessively long response time. All of them had normal visual acuity and no known auditory deficits.

Apparatus: The tasks were conducted in a dimly shielded room. Each subject was seated facing a box to which a patch was attached for light presentation. The visual stimulus (light) was projected onto inner side of the patch which was 50 cm distant from the S's eyes. To the subject, the light subtended a visual angle of 0.7°. When the light was off, this patch's circle served as a fixation point since the circle let the light of the room in to the box. The auditory

stimulus was a 4000 Hz, 39 dB SPL tone presented binaurally via headphones. The sound level was measured by Artificial Ear (Type 4152, Brüel & Kjær).

Procedure: After allowing a moderate time for adapting to the darkness, each subject was asked to matched the light to the tone which they perceived to be of equivalent intensity by the method of limits. Stevens and Marks (1965) showed that cross-modality matching between the brightness of light and the loudness of a tone is possible. The light and tone were presented simultaneously for 1 sec and the subjects were asked to compare the brightness of the light with the loudness of the tone. Six equivalent intensities were obtained by three ascending and three descending series. The average of these six was the intensity used in the subsequent reaction task.

The task of the subjects was to response to the stimuli as fast as they could. Each subject was given two kinds of bimodal reaction tasks, that is, a choice reaction task and a simple reaction task.

In the choice reaction condition, Ss were asked to press one key as soon as they heard the tone or another key when they saw the light, using the corresponding right or left hands. The correspondence of right and left hand to the light and tone were counterbalanced within reaction conditions. When two stimuli were given paired, Ss were instructed to react to the stimuli that they recognized first.

In the simple reaction task with two modalities, the subjects were asked to press the same key for light, tone, or pair of them. When two stimuli were given paired, the subjects reported the stimulus they recognized first orally after the keypress.

After 4 practice trials, the test trials were given. Each of these two bimodal conditions consisted of 30 trials, including 25 trials with light or tone. The ratios of light and tone within the tasks were almost the same. In the remaining 5 trials the light and tone were presented simultaneously. The light, tone, and pair of them were presented in a random sequence.

The two kinds of simple reaction tasks with the light or tone were also conducted for all Ss. Subjects were told whether light or tone would occur before the task performance. Each task consisted of 4 practice trials and 30 test trials and the same stimulus was given on every trial.

Light and tone onsets were controlled by a microcomputer. Reaction times were measured to the milliseconds. In all reaction tasks, the verbal instruction was followed by an auditory warning click which preceded the response stimulus by 1 to 2 sec randomized with a mean of 1.5sec. The intertrial interval was randomized with a mean of 6 sec and a range of 5 to 7 sec.

The stimulus was presented for a maximum of 1 sec. And the keypress terminated the stimuli presentation. When no reaction was given for 1 sec or the reaction was given within 50 msec after the stimulus onset, the trial was discarded as an error and another new trial was added.

Each subject was given all of the four tasks, choice and simple reaction tasks with two modalities, and simple reaction tasks with vision or audition. The sequences of these tasks were counterbalanced within subjects.

Results

Judgments on the paired trials: The percentages of judgment on the paired trials are shown in Fig. 1. In the choice reaction condition , 39 (71%) of 55 trials were not to the auditory but to the visual stimuli. In simple reaction condition, 38 (69%) of 55 were to the visual stimuli. The results of *chi-square* test indicated that the number of visual responses was significantly different from 50% chance level ($X^2(1) = 9.618$, $p < .01$, choice reaction; $X^2(1) = 8.018$, $p < .01$, simple reaction). The ratio of visual responses had no significant difference between the two reaction conditions ($X^2(1) = 0.043$, n.s.).

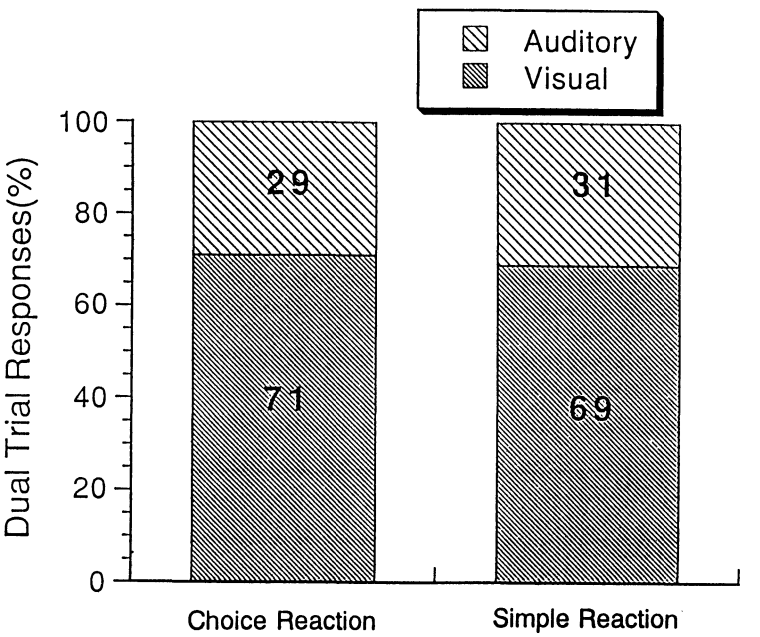

Fig. 1. Percentage of visual and auditory responses on paired trials in the bimodal stimulus condition. The ordinate shows the percentage of visual and auditory responses. The abscissa shows the reaction condition. The upper part in the bar represents auditory response and the lower part represents visual response.

Reaction times: The mean simple RTs for light and tone trials in one modality tasks were 215 and 199 msec, respectively. The result of t-test showed that the significant difference of light and tone simple RTs was significant ($t(8) = 2.752$; $p < .05$).

Mean visual and auditory RTs on paired trials and mean visual and auditory RTs on single trials in bimodal tasks are shown in Fig. 2 and 3, respectively.

Since the bimodal and single trials actually involved different kinds of tasks, a separate analysis was performed on the RTs. Reaction times on the paired trials was the average of the data of 9 subjects since two of the subjects had no tone responses on the paired trials. No statistical analysis was given to these RTs because of the different numbers of samples for the average RTs. While visual RTs seem to be the same as auditory RTs, RTs in choice reaction

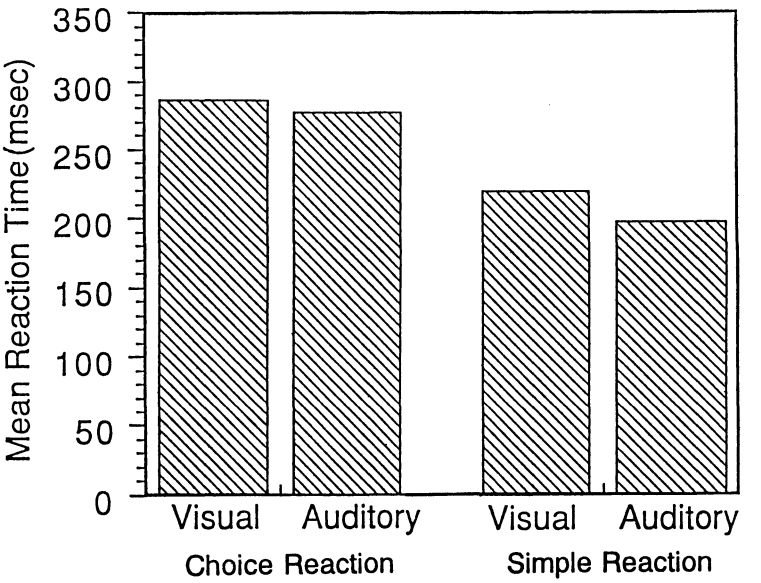

Fig. 2. Mean visual and auditory RTs on paired trials in bimodal stimulus condition (in msec). The ordinate shows the mean RTs. The abscissa shows the reaction condition. The bars from left to the right represent alternating visual and auditory conditions.

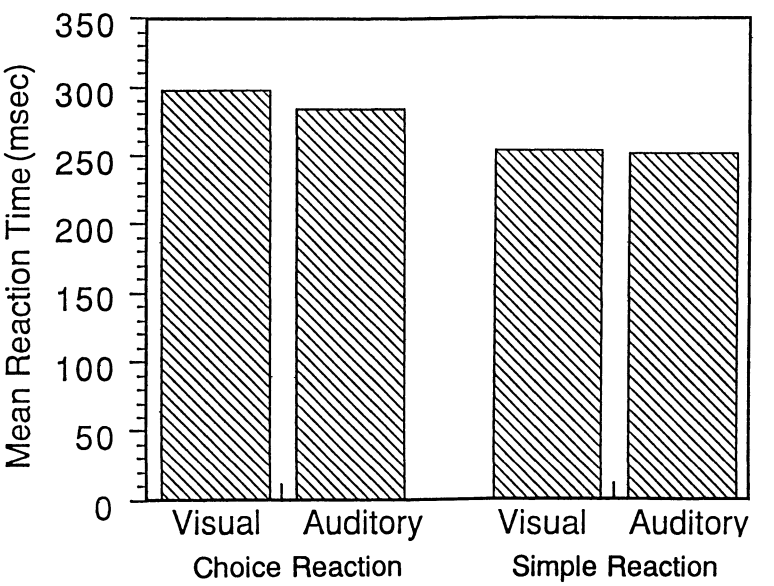

Fig. 3. Mean visual and auditory RTs on single trials in bimodal stimulus condition (in msec). The ordinate shows the mean RTs. The abscissa shows the reaction condition. The bars from the left to the right represent alternating visual and auditory conditions.

seem to be longer than RTs in simple reaction.

As for the RTs on single stimulus trials in bimodal reaction tasks, a two-way analysis of variance about the reaction situation and modality was performed. In sequence there were no difference in two modalities ($F(1,10) = 0.78$, n.s.), but there were difference between reaction situations ($F(1,10) = 10.46$, $p < 01$) and no interaction ($F(1,10) = 0.90$, n.s.)

Errors: There were ten errors that involved errors of wrong keys and errors of wrong timing. However, no bias were found between two modalities, so no analysis was conducted.

Discussion

The present study demonstrated that the light tends to be recognized first when the light and tone are presented simultaneously under subjectively equivalent intensities, and that this visual dominance phenomenon was observed not only in the choice reaction task but also in the simple reaction task.

In this study, a hypothesis was presented, that is, the process of choosing a response will have an influence on visual dominance. Nevertheless, the results obtained indicate that a choice of response is unnecessary for visual dominance. The simple RTs in bimodal reaction task was longer than the simple RTs in one modality. This fact suggests that simple reaction in bimodal reaction task includes some processes in addition to the reception of signal, identification of signal, and the initiation of action.

In the bimodal tasks, the trials requiring the order judgments of the stimuli was interspersed in a random manner. So there is the possibility that a selection process is also present in the simple response in the bimodal tasks. However, the present results indicate that the key selecting process in a choice reaction task does not affect the visual dominance. Therefore it can be concluded that there is no bias of response in paired trials resulting from the key selecting process, although other selection processes affecting visual dominance may be present.

The stimuli used in this study was very simple light and tone. Though the process of stimulus identifying was not examined in this study, what effect does identification of the stimulus have on the visual dominance ?

Colavita (1974) showed that a tone of twice the intensity of the light did not decrease the number of light responses on his bimodal trials. Egeth and Sager (1979) also found that the visual dominance was not influenced by the intensity of the light. According to these findings, the visual bias might not be sensitive to the intensity of the stimulus. In addition, the other feature of the stimulus, for instance the color of the visual stimulus and the frequency of the auditory stimulus were decided by the experimenters' will. These facts led us to suppose the possibility that some feature of the stimulus affects identification of the stimulus.

In summation, two findings have been shown in the present study. 1) the visual input is dominant in the bimodal reaction task with the non-discordant stimuli. 2) the visual dominance is not due to key selecting process.

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(Received November 10, 1992)
(Accepted January 20, 1993)